Process Development of Fission Mo in Korea

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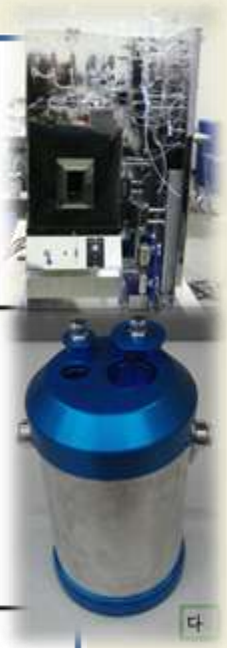
Overview

- Background
- Kijang NRR
- FM Activities and Highlights
- Current Research Activities
- Target Development
- Process Development
- Future Prospects
- Summary

Strategic Plan Established in 2008

Shortage of Tc-99m

Short Term Immediate	Solvent Extraction	Pros	➢ Ready to supply ^{99m}Tc
		Cons	➢ High Labor Intensity ➢ Difficulty in 99mTc Trans.
Mid Term 2 years	$(n,\gamma)^{99}Mo/^{99m}Tc$ Generator	Pros	➢ Cope with Prolonged Stoppage ➢ Less Restricted and Mass Prod.
		Cons	➢ Limited to Less than 500mCi Cap. ➢ Available Basic Technology but Need Research
Long Term 5~10 years	New Reactor and Use of LEU	Pros	➢ Ultimate Solution ➢ Free from Foreign Supply and Some Exporting
		Cons	➢ Long Term Approach even with Foreign Technology



Background

- **Insecurity of Mo-99 Supply in Korea**

  ➔ Major issue

  – Self-sufficiency of RI demand became an issue for health care

  – Require to secure the medical welfare

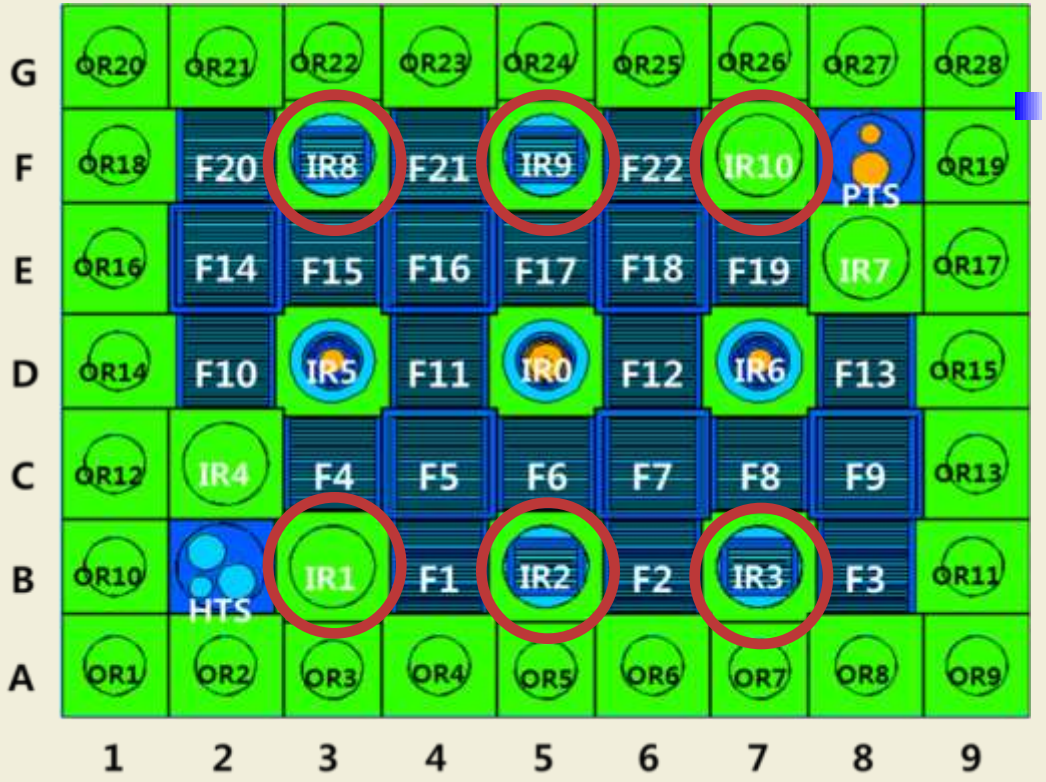
New Research Reactor Project

- Launched in 2012
- Phase: Conceptual and Basic Design
- Aiming for 1st Criticality: 2017
- Fission Mo Production Capacity: 2,000Ci/w
- NTD, Ir-192, I-125, Lu-177 etc.

Ki-Jang New RR

Item	Value
Reactor power(MW)	~15
Reactor type	Pool type
Max. thermal neutron flux (n/cm^2s)	> 3.0×10^{14} n/cm^2s
Operation day per year	~300
Reactor life(year)	50
Fuel	LEU U-Mo plate type (U loading : ~8.0 g/cc)
Reflector	Beryllium
Coolant and flow direction in operation	H_2O, downward forced convection
Reactor building	Confinement
Decay heat cooling	Passive system

Conceptual Design of Core



Mo-99 Production (8 days)

- **1 RIG >400 Ci**
- **4 RIGS > 1,600 Ci**
- **6 RIGS > 2,400 Ci**

w/ 85% Chemical Yield
> 2,000Ci (8day)

OPL Mechanism for FM Irr. Holes

FM Research Activities

- **1st Feasibility Study (1987 ~ 2001)**
  - 'HANARO' RR Project
  - Feasibility Study Using HEU
  - A Hot Cell Bank was Reserved for FM Production -> Currently Tc-99m Generator Production Bank
  - Researchers: Retired
- **2nd Study (2001 ~ 2006)**
  - HEU → LEU
  - LEU Foil Target (IAEA/RERTR)
  - Target Oriented
  - Feasibility Study on MIP (50kW Solution Reactor for FM, I-131 and Sr-89)
- **3rd Activity (2012 ~)**
  - 'New Research Reactor' Project
  - UAlx (LEU) Target + Process + Facility (2,000Ci FM)
  - Process development : Still beginning stage
  - No Specialist Available

Highlights from Former Activity

U foil fabrication by Roll Casting for Mass Production

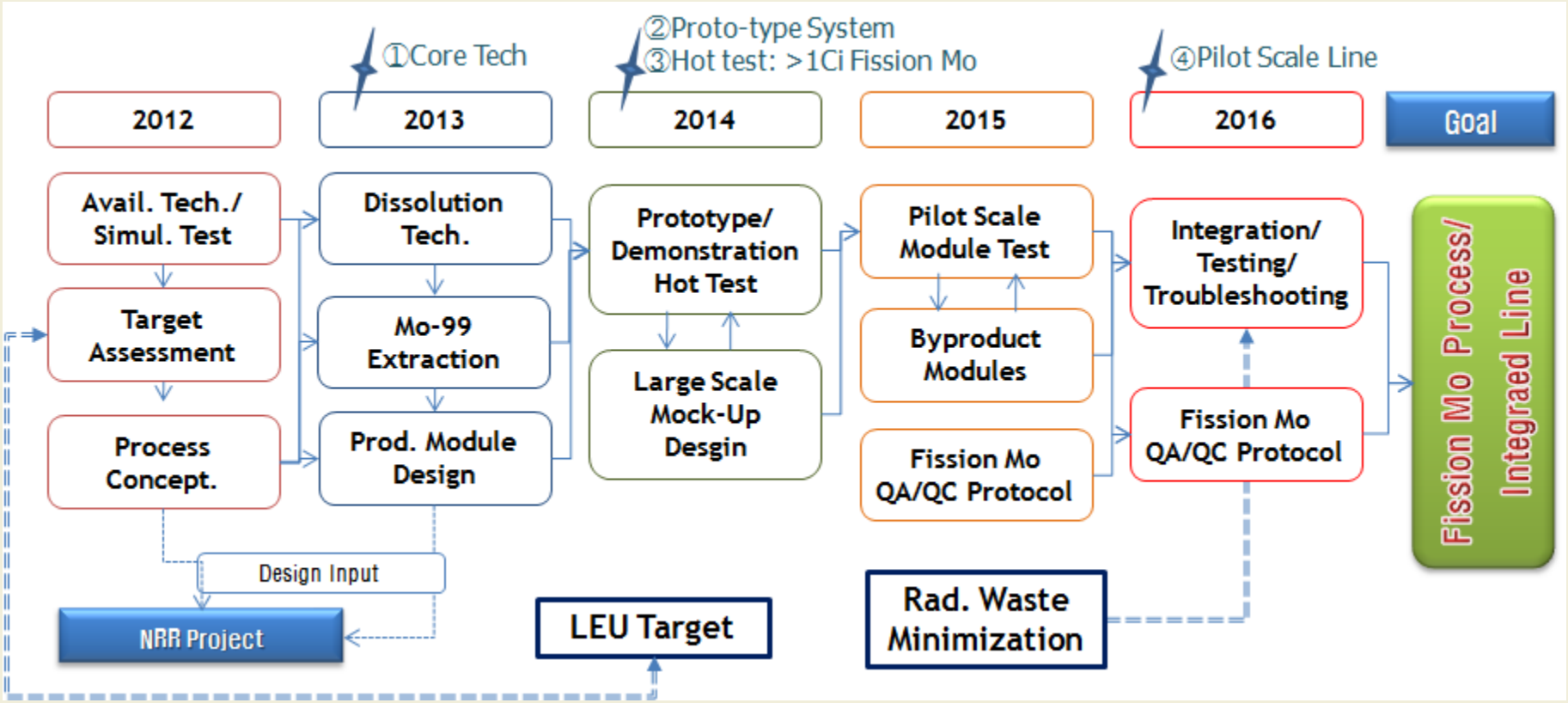
Uranium Foil Fabrication System

Crucible and a rotating Cu roller

Uranium Foil for Y12 in 2013

- NU 84 g (Germany Origin)
- LEU 99 g (19.75%, US Origin)
- Each 8 Samples

Process Development Plan



Current Research Activity

- Target
  - 3g U/cc with Atomized UAlx + Al
  - ≥6gU/cc with Atomized U + Al
  - Expectation: 40 ~ 50Ci/target (UAlx)
  - 8 Targets/Rig
  - 6 Rigs/Batch of Irradiation

- Production Process
  - Base Dissolution
  - Alumina Adsorption/Purification
    (Column but Batch also Under Consideration)
  - I-131 Recovery for Drug Manufacturing
  - I-131 and Xe-133 Removal
    : Considered as the Most Sensitive Issue

UAlx Powder Production by Atomization Technology

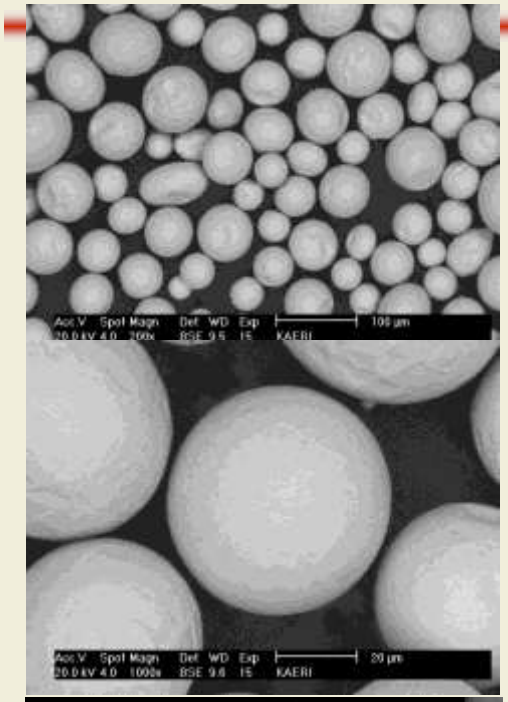
U + Al Melting -> Casting -> Heat Treatment -> Crushing

Atomization (Centrifugal Spraying)

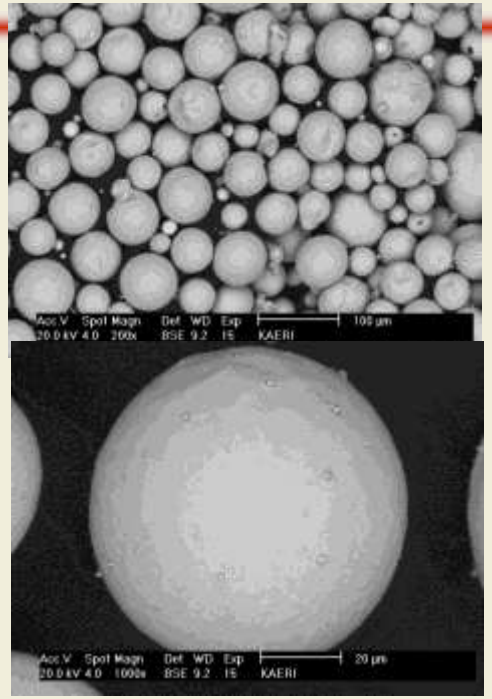
Composition	Temp. Conditions	Results
U-1wt%Al	Solid in Al Solution Melting at 1,130°C	- Grain refinement : ~ 1 um
U-10wt%Al	Melting at 1,550°C	- 27 vol.% U + 73 vol.% UAl_2 - Density: 11.1 g/cc - Uranium density: 9.95 g/cc
U-20wt%Al	Melting at 1,600°C	- 76 vol.% UAl_2 + 24 vol.% UAl_3 - Density: 7.8 g/cc - Uranium density: 6.26 g/cc

Atomized UAlx Powder

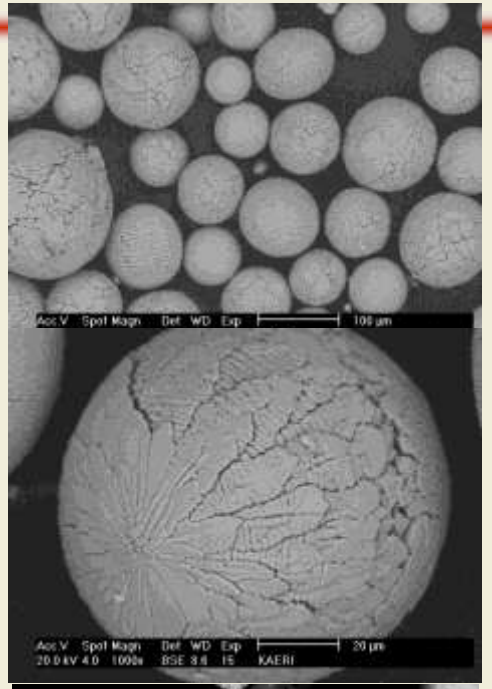
U-1wt%Al

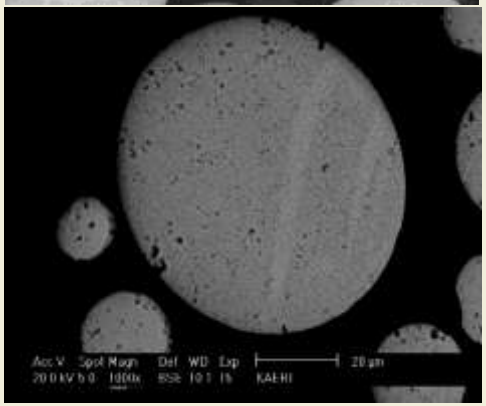


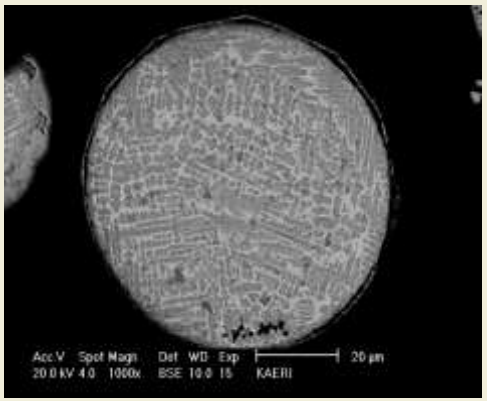
U-10wt%Al

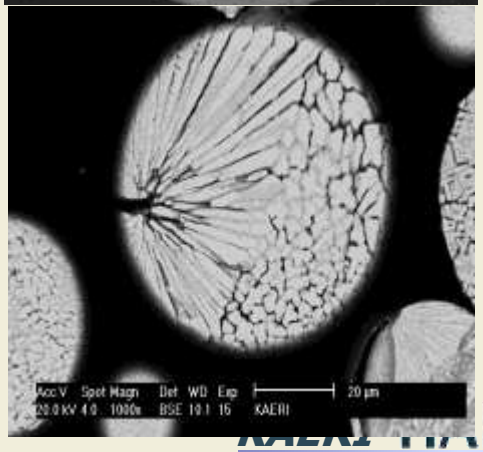


U-20wt%Al



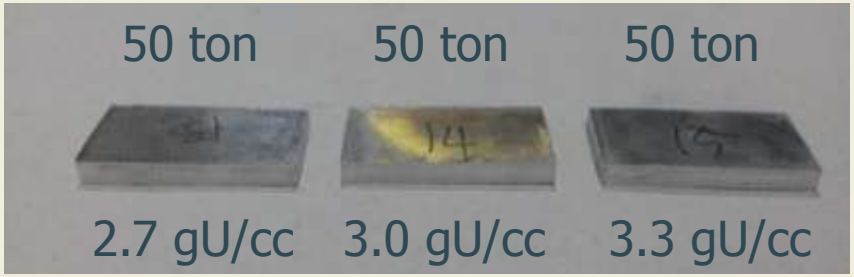


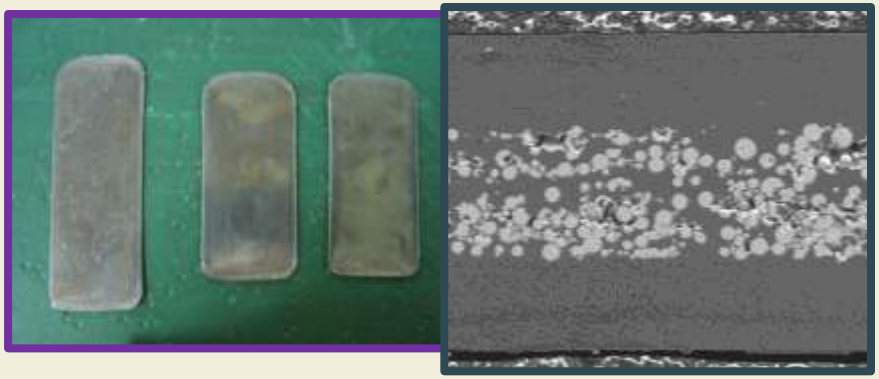




Target Preparation

- Pelletized
- Hot Rolled

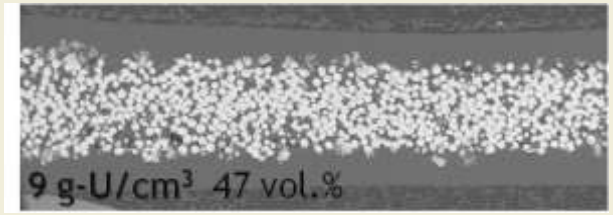




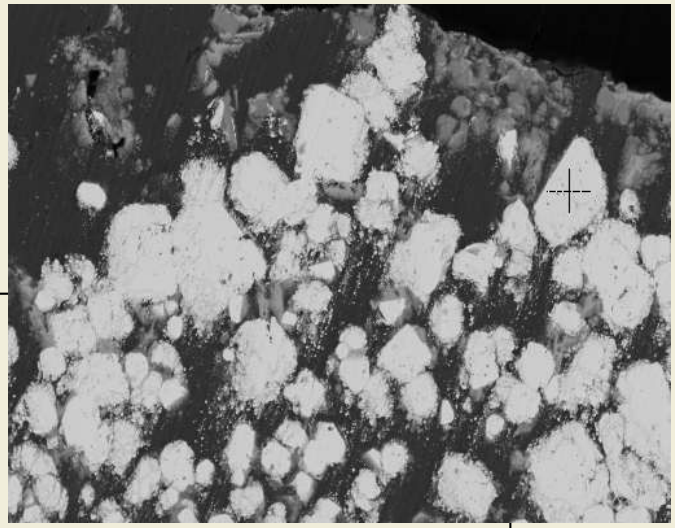
9g_U/cc Target Preparation

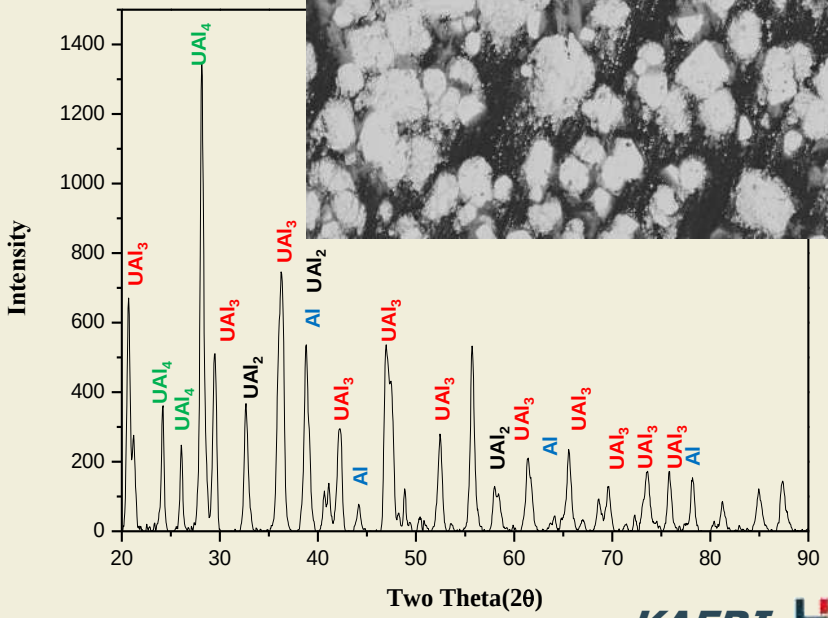
- Atomized U Powder + Al + Heat Treatment

UAl_x phase was formed by annealing of uranium dispersion samples: @700°C for 1hour.



Dissolved in Alkali? Yes





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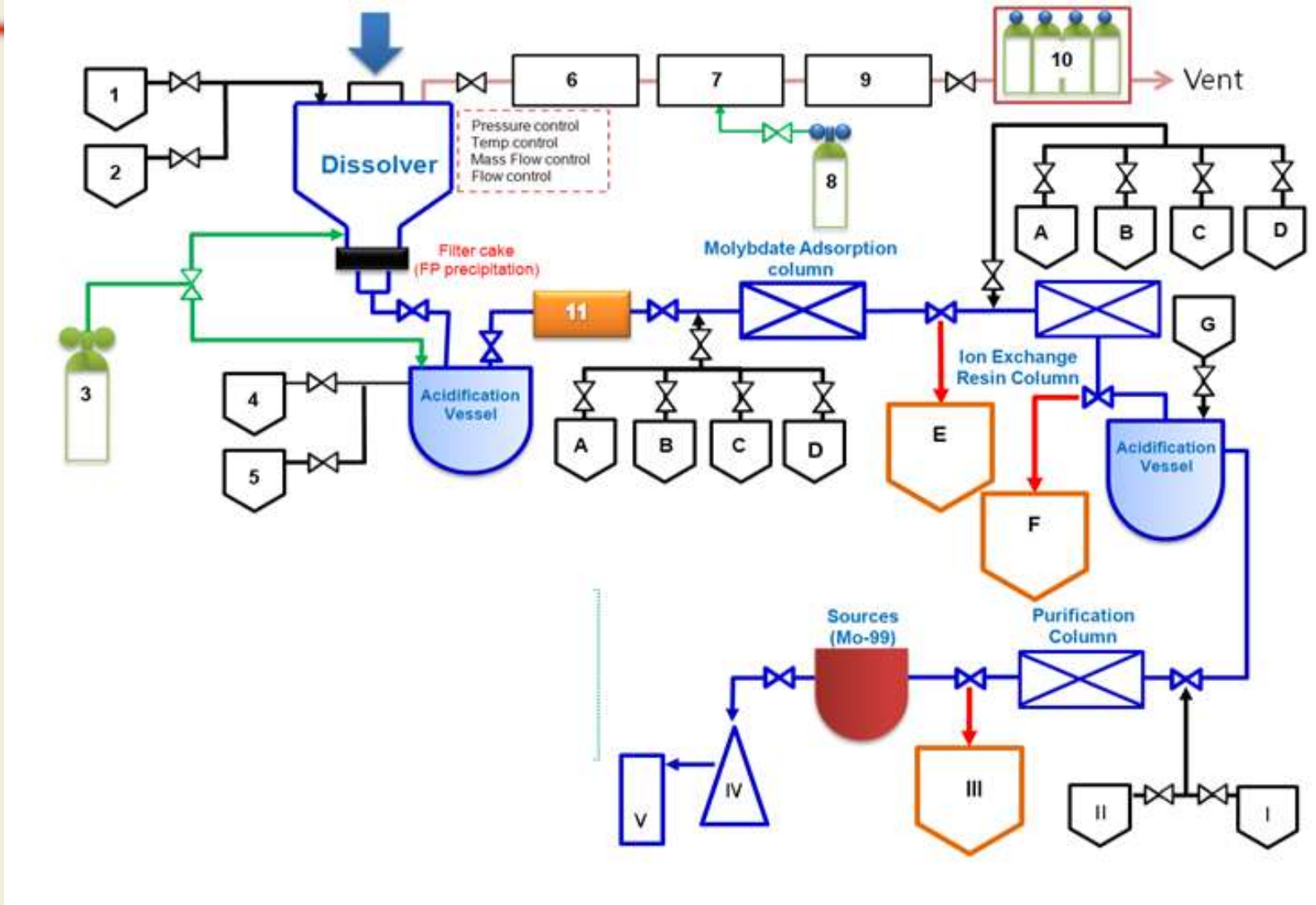
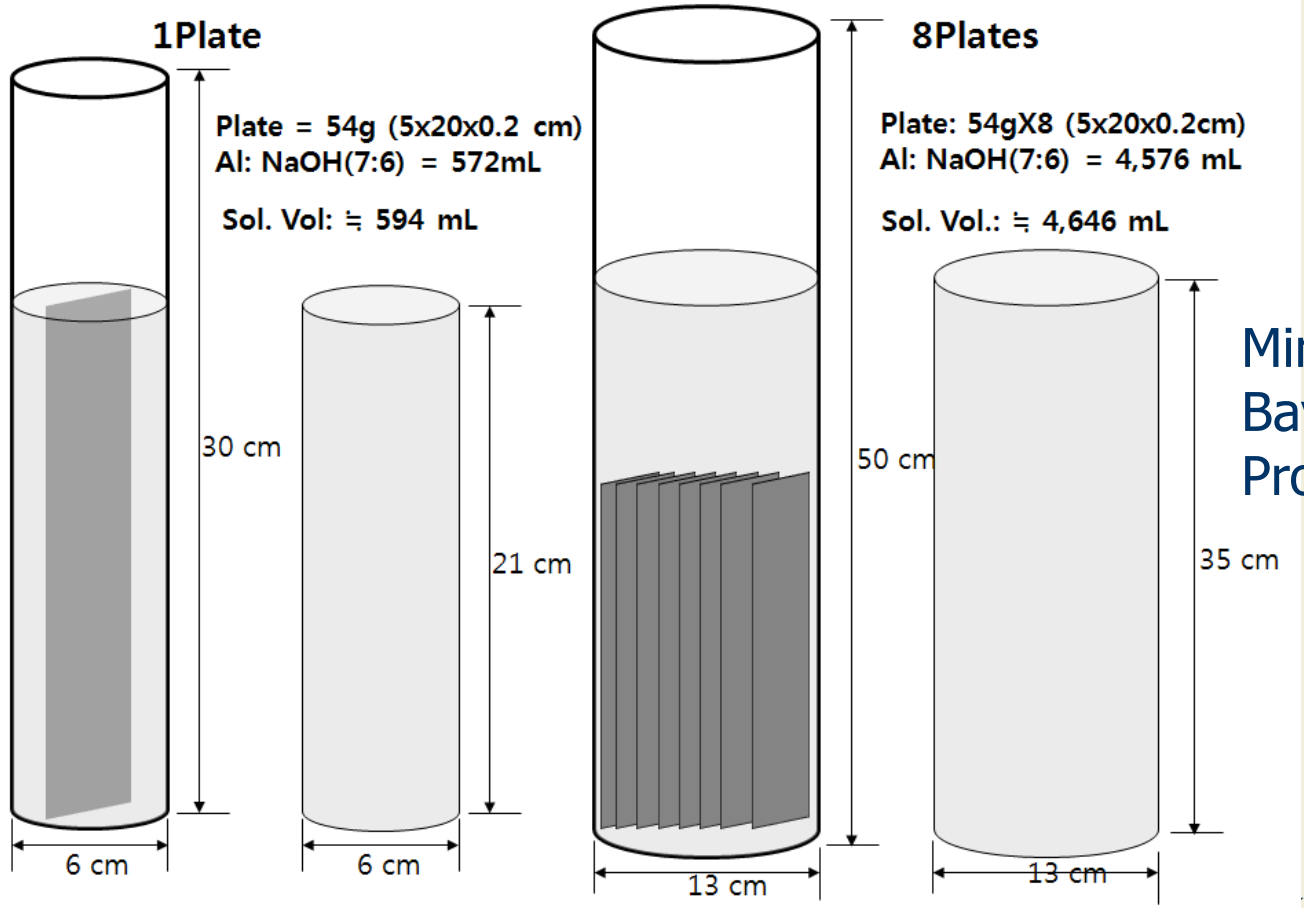
Conceptual FM Production Process



Process Development

- Dissolution of Aluminum (Al 6061)



Mimic to
Bayer's Alumina
Production Process

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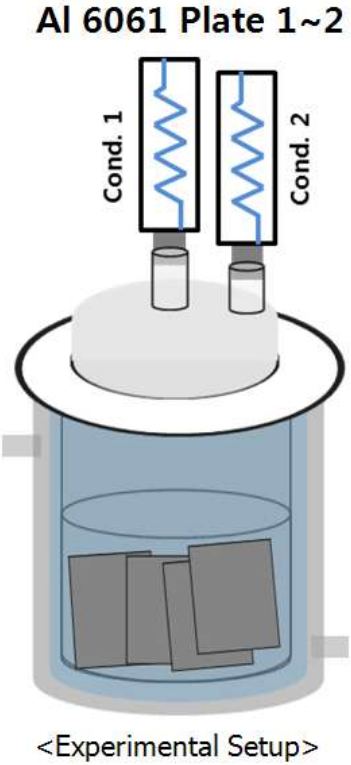
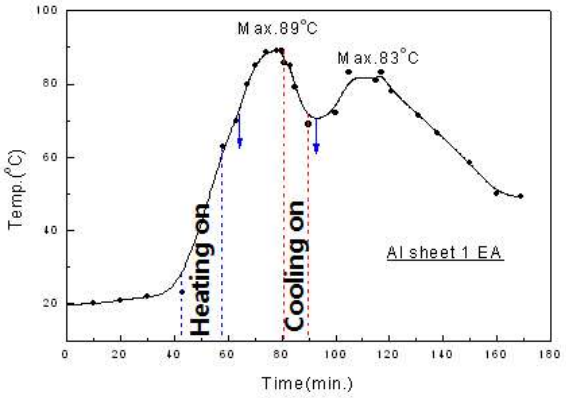
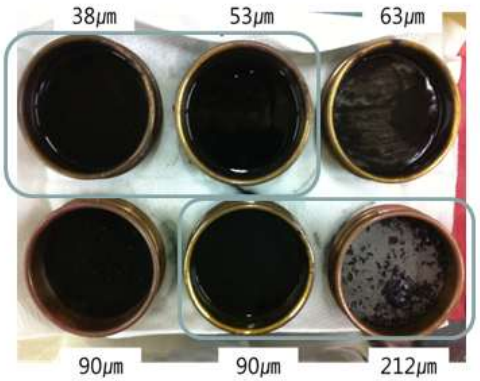
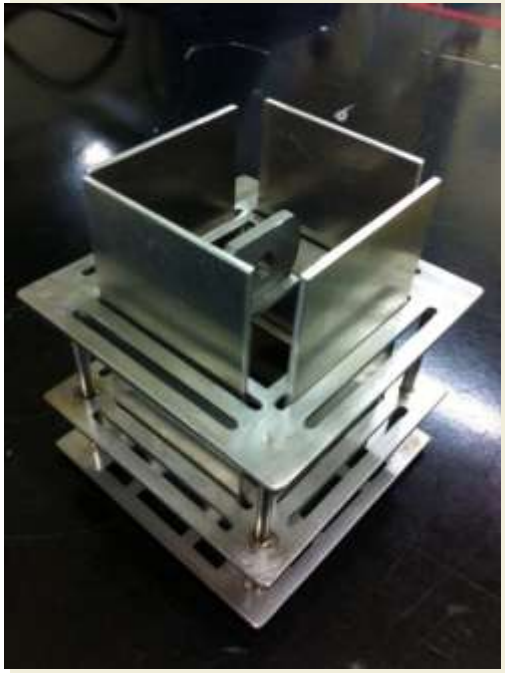
Dissolution Experiment (Only Al)



<Experimental Setup>







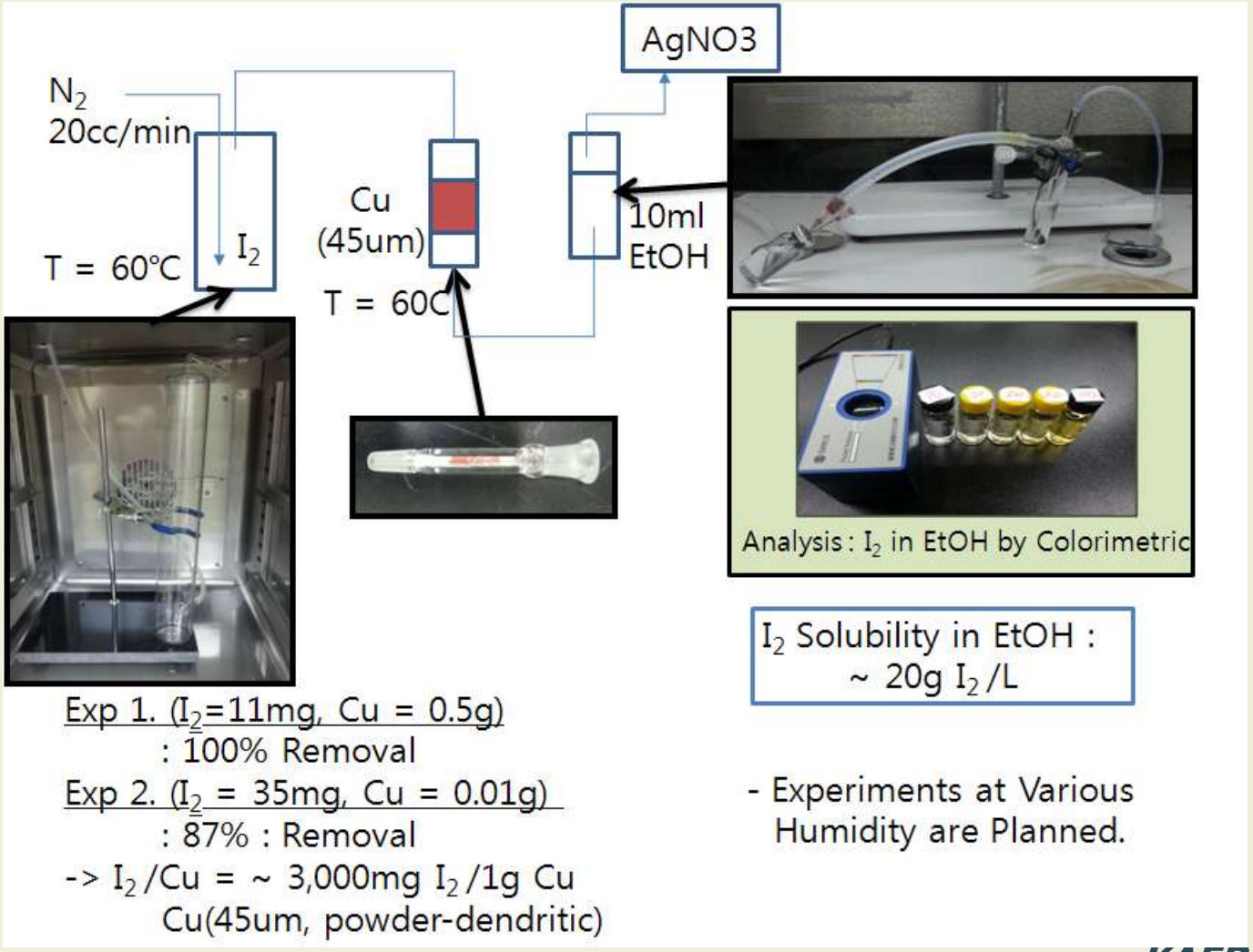
Rag for Al Plate Dissolution

Aiming to determine
- Dissolution Conditions
- Particle Size Distribution

Gaseous Iodine Trap

- Release of Radioactive Iodine to the Environments is One of the Greatest Concerns.
- Approximately 1,800Ci/Target of Fission Iodine is expected at the Processing Time.
- Various Trapping Materials are Under Considered. Cu powder and Pt on Cu are Most Probable Trapping Materials for the Recovery of I-131.

Gaseous I_2 Removal and Analysis



Exp 1. (I_2=11mg, Cu = 0.5g)
: 100% Removal

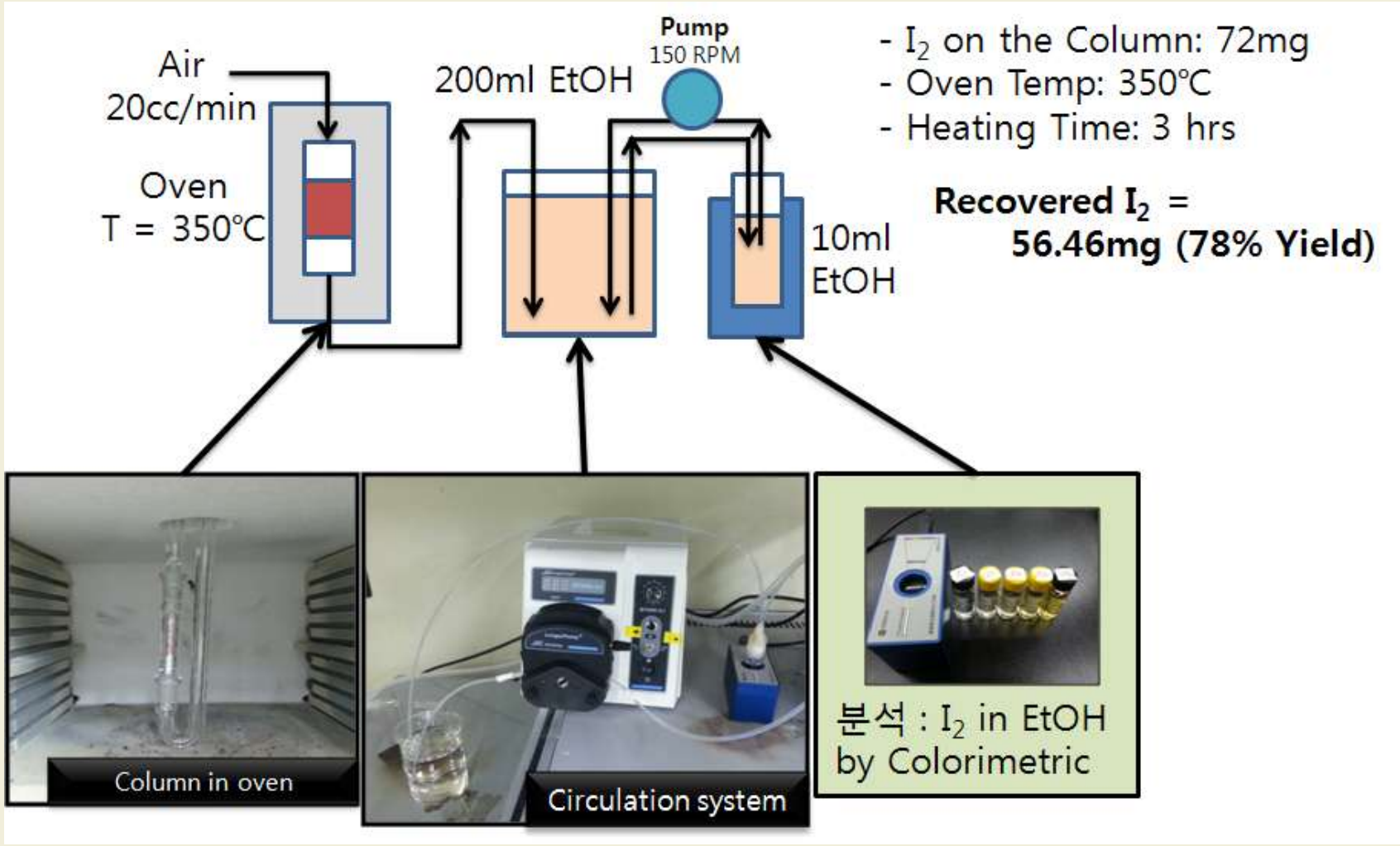
Exp 2. (I_2 = 35mg, Cu = 0.01g)
: 87% : Removal

-> I_2 /Cu = ~ 3,000mg I_2 /1g Cu
Cu(45um, powder-dendritic)

I_2 Solubility in EtOH :
~ 20g I_2 /L

- Experiments at Various Humidity are Planned.

Gaseous I_2 Recovery from CuI



Summary

- More than 20 years of FM Process Development has no Real Outputs.
- Domestic and International Environments Pushed to Construct NRR and FM Facility
  - Aiming 2,000Ci of FM
- Notable Progress in Target has been Made.
- Still Struggling in the Fundamentals of FM Process
- FM Facility Design is Time-Taking
  - But, Most Concerns are on Iodine and Xenon Release
- Expected some breakthroughs in this year in both FM Process and Facility Design.
- International Technical Supports or Consulting Specially on Facility Design are Greatly Necessary for Us to Succeed in FM Production in Korea and also in the Region.

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THANK YOU